

United States Army School of Aviation Medicine
Fort Rucker, Alabama
August 2003



LESSON PLAN

TITLE: GRAVITATIONAL FORCES

FILE NUMBER: U3004504-1

PROPONENT FOR THIS LESSON PLAN IS:

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Gravitational Forces
U3004504 / Version 1
12 Aug 2003

Prerequisite Lesson(s)

<u>Lesson Number</u>	<u>Lesson Title</u>
None	

Clearance Access

Security Level: Unclassified
Requirements: There are no clearance or access requirements for the lesson.

Foreign Disclosure Restrictions

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References

<u>Number</u>	<u>Title</u>	<u>Date</u>	<u>Additional Information</u>
0-7817-2898-3	Fundamental of Aerospace Medicine, 3rd Edition		
FM 3-04.301	Aeromedical Training for Flight Personnel	29 Sep 2000	

Student Study Assignments

Study SH and review reference material listed above.

Terminal Learning Objective

Action:	Manage the effects of Gravitational Forces.
Conditions:	While performing as an air crewmember
Standards:	In accordance with (IAW) FM 3-04.-301 and Fundamentals of Aerospace Medicine.

Safety Requirements

None.

Risk Assessment Level

Low

Environmental Considerations

NOTE: It is the responsibility of all soldiers and DA civilians to protect the environment from damage. None.

Evaluation

On the last day of aviation medicine academics, each student will be evaluated on this block with a 50 question examination in which they must answer 35 of 50 questions correctly to receive a passing score. The test will be given in room X110 of Bldg 301.

A. ENABLING LEARNING OBJECTIVE

ACTION:	Define gravitational force terms
CONDITIONS:	Given a list of terms and definitions
STANDARDS:	IAW FM 3-04.301 and Fundamentals of Aerospace Medicine

- a. "G" is the measure of the magnitude of an accelerative force with respect to gravity.
 - (1) Equal to 32.2 feet per second squared.
 - (2) Acceleration continues until terminal velocity is reached.
- b. Acceleration is the rate of change of velocity with respect to time.
- c. Deceleration (negative acceleration) is a reduction in the velocity of a moving body with respect to time.
- d. Inertia is the resistance to a change in the state of rest or motion.
 - (1) A body in motion tends to stay in motion, unless acted on by an outside force.
 - (2) A body at rest tends to stay at rest, unless acted on by an outside force.
- e. The tri-axial reference system identifies the direction in which the body receives accelerative forces.

B. ENABLING LEARNING OBJECTIVE

ACTION:	Recognize the factors of acceleration with their appropriate effects.
CONDITIONS:	Given a list of factors and effects
STANDARDS:	IAW FM 3-04.301 and Fundamentals of Aerospace Medicine.

- a. Factors of acceleration.
 - (1) Intensity--the greater the intensity, the more severe the effects of accelerative forces. (Intensity, however, is close related to duration).
 - (2) Duration--the longer the force is applied, the more severe the effects.
 - (a) Ejection seat sequences expose the aviator to approximately 15g's for about 0.1 seconds without difficulties. If this intensity was lengthen to 2 seconds the aviator would be rendered unconsciousness.
 - (b) There will be 2 to 3 minute state of unusable consciousness after normal blood pressure is returned.
 - (3) Rate of onset--the faster the rate of acceleration, the more severe the effects.
 - (4) Body area and site--the greater the size of the body area affected, the less severe the effects.

(5) Impact direction--a force in the Gy axis will not be tolerated as well as a force applied to another axis because of aircraft structural and human physiological limitations.

C. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the effects of low magnitude acceleration.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301 and Fundamentals of Aerospace Medicine.

REMINDER: Low magnitude accelerations are described as “G”s that range from 1 to 10 “G”s lasting for several seconds.

a. +Gz--during a +Gz maneuver, body weight increases in direct proportion to the force (200 pounds will weigh 600 pounds during a 3G maneuver).

(1) Circulatory effects.

(a) Blood pooling in the lower extremities.

(b) As the force exceeds 2G's, blood flow to the eye decreases causing a gradual loss of peripheral vision (grayout).

(2) +Gz tolerance limits.

(a) 1.0-2.5 Gz: Blood pooling.

(b) 2.5-4.0 Gz: Grayout.

(c) 4.0-4.5 Gz: Blackout.

(d) 4.5 and above: Unconsciousness.

(3). Factors that modify +Gz tolerance.

(a) Decremental factors are any factors that reduce the overall efficiency of the body, especially the circulatory system.

(b) Blood volume decrease.

1. Dehydration.

2. Hemorrhage.

3. Acute alcohol abuse.

4. Varicose veins.

(c) Blood pressure decrease.

1. Due to blood loss or dehydration.

2. Illness/not physically fit.

3. Acute alcohol abuse.

(4) Incremental factors are any factors that enhance the ability of the body to withstand G-forces.

- (a) Hypertension.
- (b) Fear/excitement.
- (c) Tensing of muscles.
- (d) Short stocky build.
- (e) L-1 maneuver.
- (f) Anti-G suit.

b. -Gz circulatory effects.

- (a) Result in inadequate circulation to sustain consciousness. Blood pooling and stagnation occur in the head and neck.
- (b) A rise in intracranial pressure produces head pain and visual disturbances.

c. -Gz tolerance limits.

- (a) 0.0 to -1.0 Blood pooling.
- (b) -1.0 to -2.5 Vision affected.
- (c) -2.5 to -3.0 Redout.
- (d) Over -3.0 Incapacitation.

d. Positive and negative Gx effects.

- (a) Aircrew members experience mild transverse accelerations and decelerations when taking off and landing.
- (b) Individuals are more tolerant of forces on the Gx axis because transverse G's interfere very little with blood flow.
- (c) Tolerance limits.

1. Greater than +7 or -7 G's breathing may become more difficult.

2. Some individuals have withstood up to +20 and -20 G's for several seconds without any severe effects.

e. Gy effects.

(1) Aircraft are structurally designed to handle aerodynamic loads which are transmitted to aircraft occupants primarily in the Gx or Gz axis.

- (2) This creates a structural design limitation which makes lateral accelerations (Gy axis) the most lethal to aircraft and occupants.

D. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the physiological effects of high magnitude acceleration/deceleration.
CONDITIONS:	Given a list
STANDARDS:	IAW FM 3-04.301 and Fundamentals of Aerospace Medicine.

REMINDER: High magnitude accelerations/decelerations are described as G-forces exceeding 10 G's and lasting less than a second.

a. Physiological effects.

- (1) Minor discomfort.
- (2) Minor injury.
- (3) Incapacitation.
- (4) Irreversible injury.
- (5) Lethal injury.

b. The primary source of high magnitude accelerations and decelerations are aircraft crashes. Additional sources would be ejection seats and parachuting.

E. ENABLING LEARNING OBJECTIVE

ACTION:	Recognize aircrew member survivability criteria.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301 and Fundamentals of Aerospace Medicine.

REMINDER: Occupant survivability during the accident sequence is contingent upon the following criteria:

a. Amount of crash forces transmitted.

NOTE: Human tolerances:

- (1) +Gx: 80.
- (2) -Gx: 40.
- (3) Gy axis limit is 9.
- (4) +Gz: 20.
- (5) -Gz: 16.

b. Occupiable living space. Two objects cannot occupy the same space.

c. Aircraft design features that enhance crash survivability, (CREEP).

- (1) Container.
 - (a) Acts as an effective protective shell.
 - (b) Crushable material to attenuate crash forces.
- (2) Restraint system.
 - (a) Should be comfortable and snug.
 - (b) Should adequately restrain major body parts.
- (3) Environment, make the cockpit less dangerous.
- (4) Energy absorption.
 - (a) Landing gear.
 - (b) Aircraft undercarriage.
 - (c) Seats stroking (approximately 4g's) in newer rotary wing aircraft.
- (5) Post crash factors.
 - (a) Fire.
 - (b) Evacuation.